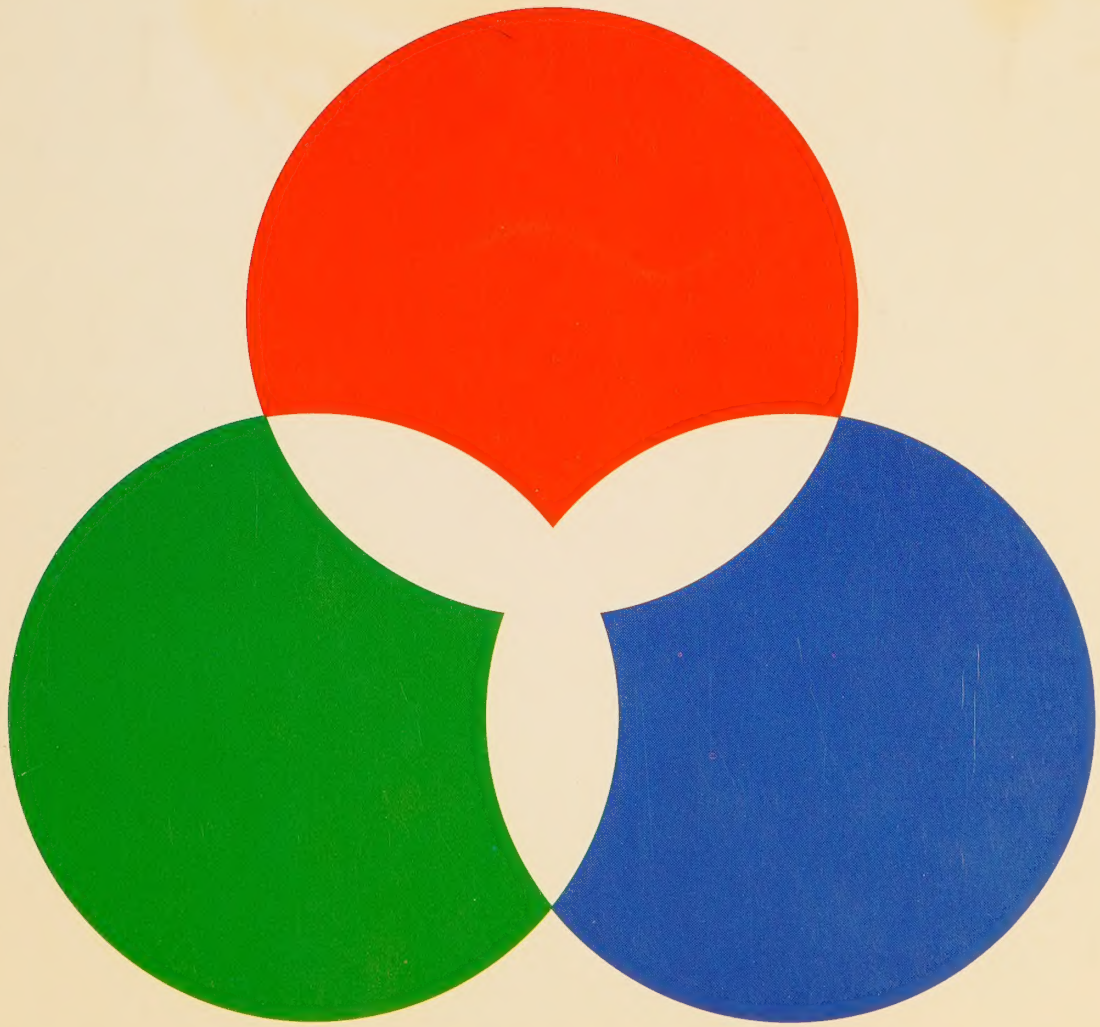
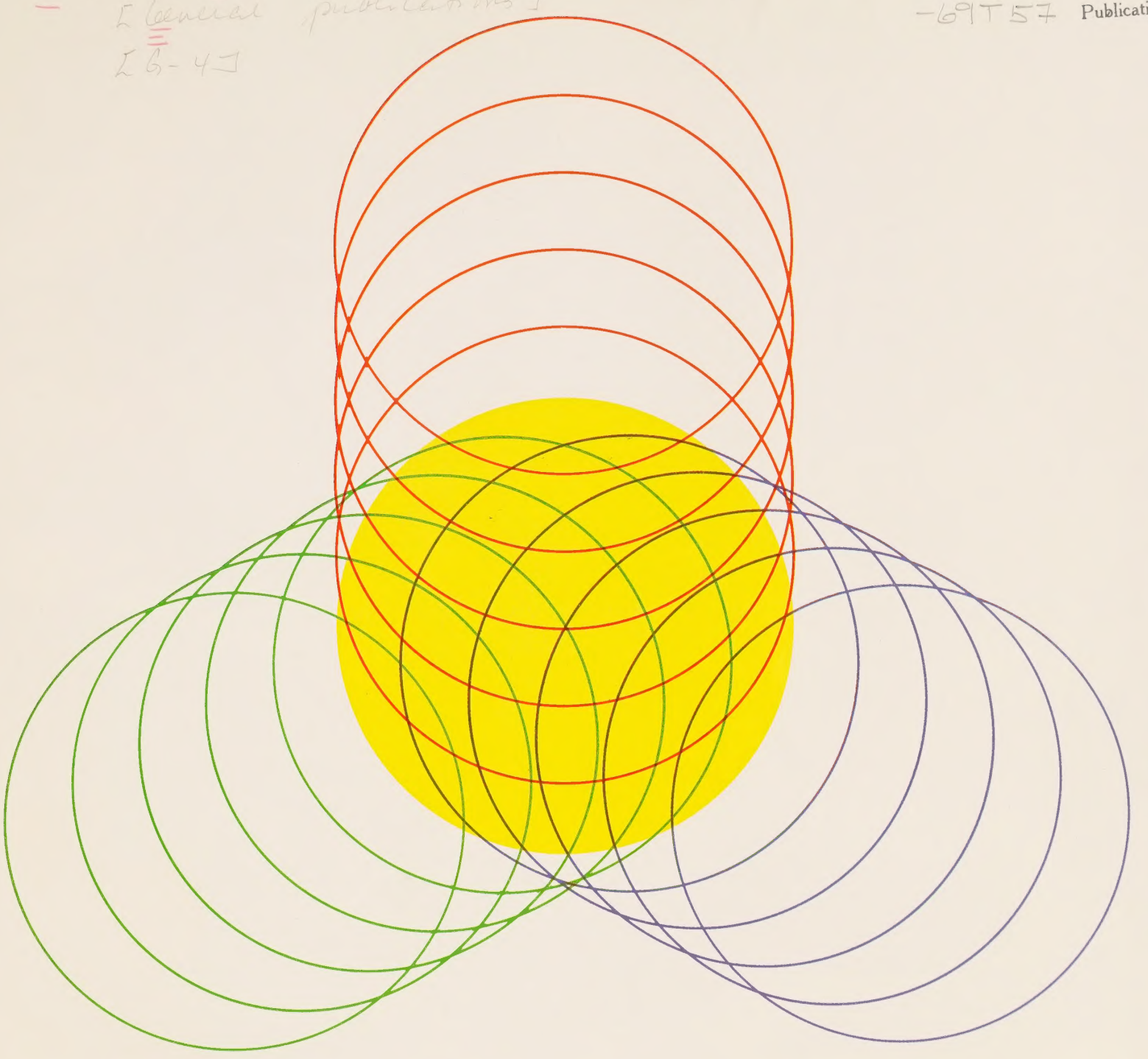
To see what everyone has seen and think what no one has thought





The story of Science is the story of change and evolution.

Protons and electrons evolve into hydrogen atoms.

Hydrogen atoms evolve into heavy atoms: helium, carbon, iron, titanium.

Atoms evolve into molecules.

Ordinary molecules evolve into elaborate molecules which reproduce themselves.

Self-reproducing molecules evolve into life.

Life evolves from lower forms to higher;
from primitive forms to more elaborate ones,
by adaptation through natural selection.

Higher animals evolve into the highest animal: man.

Man develops cultures: ways of thought, ways of living, ways of understanding.

These include science itself; and science, too, is evolving.

Science studies the world to understand it,
and to make use of it.

Scientists try to look at things carefully
and measure what they see.
The measurements may suggest
an idea, a theory, an explanation, an hypothesis.

Then the scientist tries to ask questions.
He does this by setting up a special situation which uses the idea or theory.
Often he tries to predict what will happen:
then he sees if he is right.
Science must always pay attention to facts;
the facts derived from observation and from experiment.
If a fact spoils a theory,
then the theory must go.

Science combines the resources of nature and the resourcefulness of man.

To see what everyone has seen; to think what no one has thought.

The great tragedy of Science –the slaying of a beautiful hypothesis by an ugly fact.

Science is a process of questioning.
The scientist puts the questions. He looks to nature for the answers.

The great French student of insects, J. L. Fabre,
said that in science, there is no trouble getting the right answers.
All you have to do is ask the right questions.
The answer you get is the answer to the question you *really* asked,
not the question you *thought* you were asking.

People thought you could make nitrogen from the air
by taking away oxygen, water vapour, and carbon dioxide.
What was left would have to be the nitrogen.
Nitrogen made like this, however,
was slightly different in weight from nitrogen made from chemicals.
Eventually Ramsey discovered that
mixed in with nitrogen made from the air
were the now famous rare gases, argon, neon, xenon, and krypton.

We *thought* we were asking questions about nitrogen.
We were *really* asking questions about the mixture of gases left behind
when certain things are taken away from air.

Not what holds the moon *up*?

But what holds the moon *down*?

The game of science is like a game of chess:

The chess-board is the world,
the pieces are the phenomena of the universe,
the rules of the game are what we call
the laws of Nature.
The player on the other side is hidden from us.
We know that his play is always fair,
just, and patient.
But also we know, to our cost,
that he never overlooks a mistake,
or makes the smallest allowance
for ignorance.

Progress in science is not made by asking simple questions:
it is made by asking questions that have simple answers.
You discover the proper questions by hard work and luck.
But the harder you work, the luckier you get.

WHY IS THE GRASS GREEN?

Because the leaves contain green stuff.
Let's call it chlorophyll, which simply means green-of-the-leaf.

Why is chlorophyll green?

Because white light is partly made up of the complimentary colours red and green;
the chlorophyll absorbs the red and reflects the green —
and that is what we see.

Why does chlorophyll use red light?

Because it needs exactly the energy of red light
to turn carbon dioxide and water into starch.

. . . and so on.

All these are simple questions. Not all have simple answers.
But all the answers come, not from a book, not from some authority,
but from the *grass*.


YOU HAVE TO ASK THE GRASS!

The ideas of science
should be continually checked by the facts,
otherwise theories get out of date.

It is the customary fate of new truths
to begin as heresies and to end
as superstitions.

Every new answer gives rise to new questions.

The lyf so short, the craft so long to lerne.

Isaac Newton was as great a scientist as ever lived.
But he knew how much he owed to others!
Science is cumulative.
Each man adds what he has found
to what has gone before.

If I have seen further,
it is by standing on the shoulders of Giants.

Scientists take nature seriously.
They should not take themselves seriously.

I do not know
what I may appear to the world,
but to myself
I seem to have been only like a boy
playing on the sea-shore,
and diverting myself
in now and then finding a smoother pebble
or a prettier shell than ordinary,
whilst the great ocean of truth
lay all undiscovered
before me.

We look out at the real world and find it
a strange, exciting place, full of chaos, full of change.

The world of science is a kind of frame
into which the world as we see it, can sometimes be made to fit.
In the world of science, order replaces chaos.
Science, like Art, is a declaration of order.
It is the expression of the faith that the universe lies under law,
and that we can begin to learn that law.

In the real world of endless change,
science looks for whatever endures unchanging.
Science tries to identify quantities that persist —
energy, momentum, mass.

Under suitable conditions, these things do not change — they are *conserved.*
So scientists talk about the law of the conservation of energy,
the law of conservation of momentum, and so on.

A human law tells us what we *ought* to do.
If we don't do it, we are punished (providing some one catches us!).

A scientific law makes no moral judgments,
and provides no rewards or punishments.
It simply attempts a more or less precise description of the way things
are likely to act under certain special conditions.
If these conditions are not present, then the predictions may not work either,
and the scientific law won't hold.
A scientific law is only an attempt at a tentative description.


ONE WAY TIME
SPEED
LIMIT
186,000
M.P.S.
NO
DUMPING

The real world seems to contain pairs of things that are quite different.
Space and time; matter and energy; particles and waves.

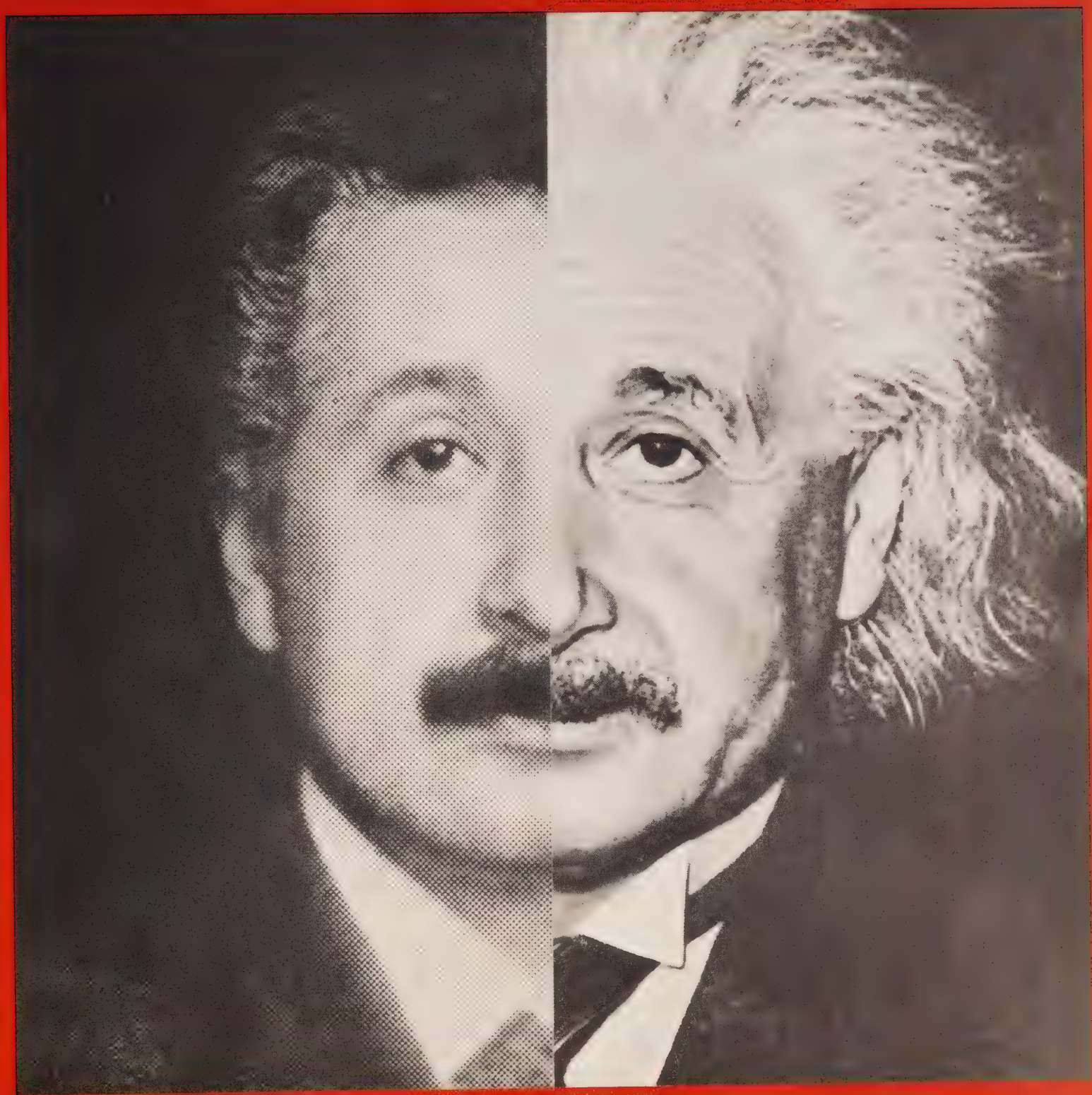
SPACE AND TIME

We measure distances in miles, and time in hours.
The real world thus seems like a box full of tape measures and rulers to measure space,
and also full of clocks to measure time.
Anybody can tell a ruler from a clock.
Space and time seem to be the twin rails on which reality runs.

But modern science has shown that space and time are aspects of one single thing.
Reality is still firmly guided, but it runs on a single rail –
the space/time monorail.
Einstein showed that the way we divide up the world and its events into space
and time depends, among other things, on how we are moving: how fast, and in what
direction. Hence Einstein's famous paradox of the twins. One twin stays home,
and the other travels in space. When finally he comes home, the travelling twin will be
younger – how much younger will depend on exactly how and where he went, and how fast.

This seems strange and unlikely –
and yet this distortion of time by movement in space that Einstein predicted
has been actually measured.

This is *not* one of those beautiful hypotheses slain by an ugly fact.
On the contrary, the facts turn out to be
just as strange and unlikely as Einstein's remarkable prediction.



Similarly there seems to be a vast difference
between the stuff in a brick
and the energy that you put in a brick by throwing it.

But once again, we discover that matter and energy,
seemingly so different,
are again aspects of one another.
And once again, it is Einstein who pointed this out.
Matter, says Einstein can be converted into energy;
at a fixed rate of exchange.
The rate of exchange is set by the famous formula
that describes the release of atomic energy.

$$E = mc^2$$

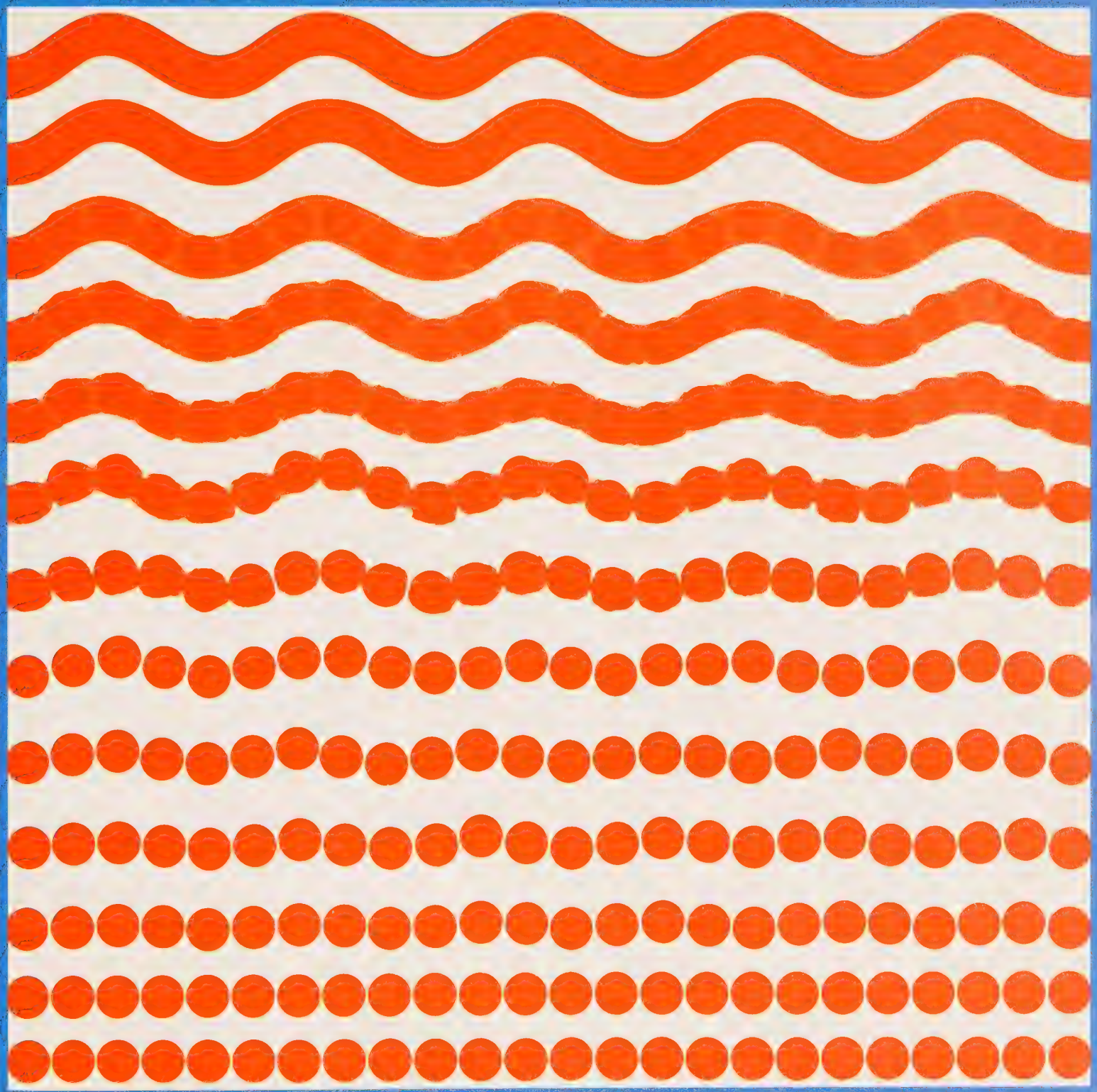
E is the energy. m is the mass. c is the speed of light, a very large number.
c^2 (c x c) is even larger.
So Einstein's equation says
that a very small amount of matter
can be converted into a very large amount of energy.

The sun gets its energy
by annihilating hydrogen at the rate of
about a trillion pounds per second.
Even so the sun will last about
ten million years.

In the same way,
the world seems full of particles – like water dripping from a hose,
and waves – like the waves on the seashore;
and waves and particles seem quite different.

But what about light? Is it made of waves or particles?
Some experiments show that light often acts like a system of waves;
but other experiments show that light also acts
like streams of bullets.

Similarly, a television screen is brought to life
by a shower of electrons directed like a stream of bullets.
Electrons plainly seem to be particles;
the electron is, in fact, one of the fundamental particles of the universe.
But we see that, if the electron stream is arranged differently,
electrons can also act like waves.
In fact, just as we can take photos with light waves,
we can also take photographs
with the much smaller electron waves.
Once again, waves and particles,
which at first seemed so different,
turn out to be aspects of one another.
Its been suggested that they really ought to be
all called *wavicles*.



Modern science has shown
that the order underlying the real world is not what we thought,
and that things we believed were quite separate are,
in fact, subtly and beautifully related.
To put it another way,
we were getting unsatisfactory answers because
we were not asking the right questions.

NOT

Is this a wave or a particle?

BUT

When does this act like a wave; when does it act like a particle?

Some of the stuff in the universe is in the form of matter,
and some is in the form of energy,
All this stuff is continually acting and interacting:
pushing, pulling, twisting, and so on.
These interactions are called *forces.*
The world contains electric, magnetic, gravitational, nuclear, and other forces.
Some of these are very strong; electrical forces, for example.
Some, like gravity, are very weak.
On earth, we are so accustomed to the dominating force of gravity
that we think of it as very strong. But if you rub a comb on your sleeve,
you can easily generate enough static electricity to pick up a piece of paper.
This means that you have generated enough electrical force
in the little comb
to counteract the gravitational pull of the entire earth.

What's in the universe?

First, nothing.

Second, nothing.

Third, still nothing.

Fourth, a little radiation.

Fifth, a little dirty hydrogen.

Most of the matter in the universe is in the form of hydrogen,
the simplest of all the elements.

An atom of hydrogen consists of one proton and one electron.
Protons and electrons are two of
the fundamental particles of the universe.
The stars are mostly hydrogen;
the great spiral galaxies are mostly hydrogen.

Look at a starry sky, and you look at glowing hydrogen.

Look at a photograph of a galaxy,
and you are looking at swirling hydrogen.

Turn the radio telescope into the night sky.
On the twenty-one centimeter band, there's a characteristic sound:
the song of hydrogen.

Nobody knows how the universe started.
Some scientists think it began with a gigantic explosion
in a huge ball of primitive matter.
This is the Big Bang Theory.

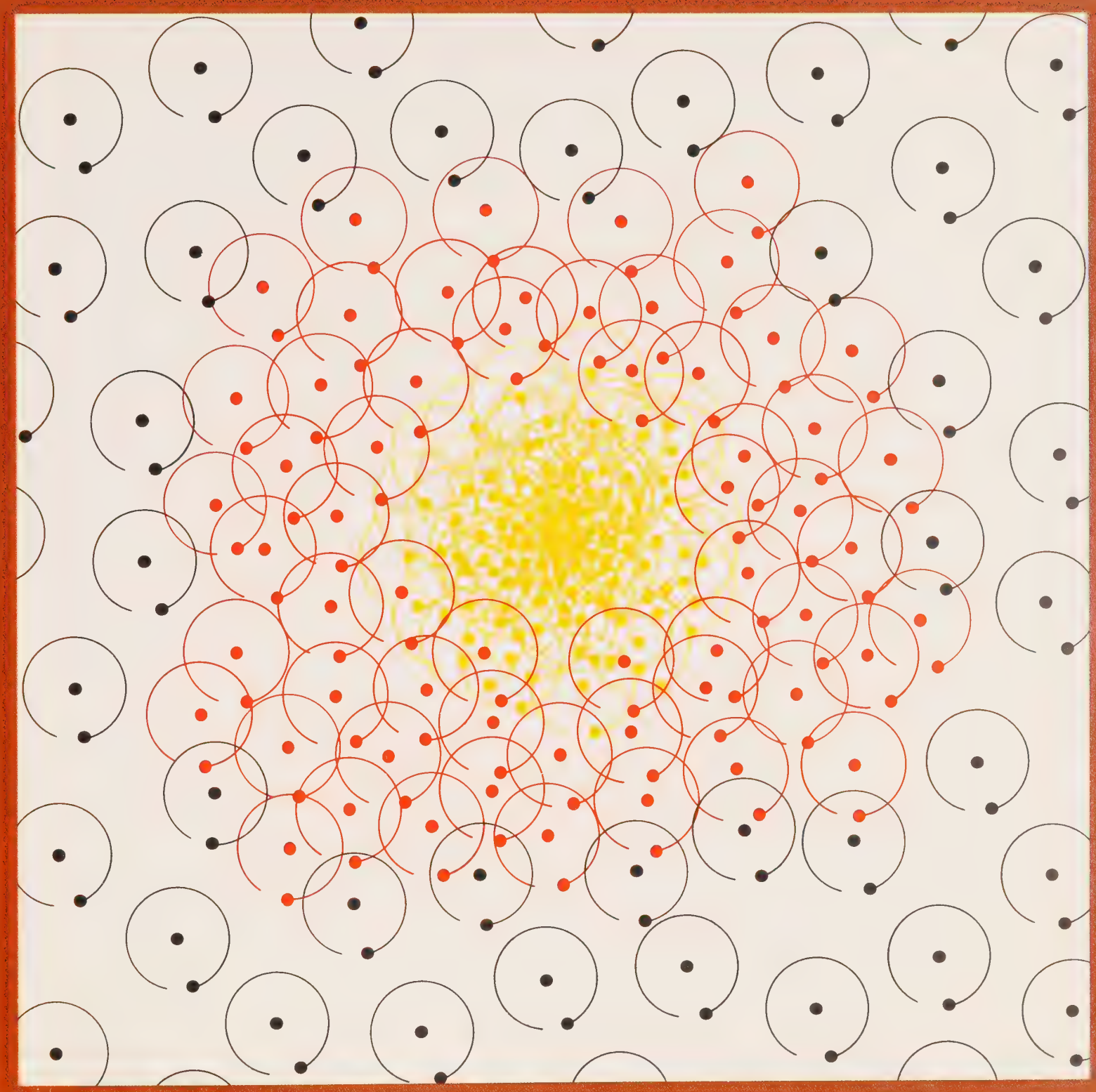
Other scientists think it has always been roughly the same as we see it now:
always expanding, and with new matter constantly appearing
to take the place of the matter that is disappearing out of sight.
This is the Steady State Theory.

At the moment
the evidence seems to favour the Big Bang Theory.
The point is that this will be decided (if at all)
not by discussion, or by asking authorities,
or by looking things up in old books,
but by looking out into space where we think the universe itself
may still bear the scars of its birth.
The point will be settled by observation,
not by theoretical discussion.
Our question will be answered, if at all,
by the universe itself.


I stood upon that silent hill
And stared into the sky until
My eyes were blind with stars and still
I stared into the sky.

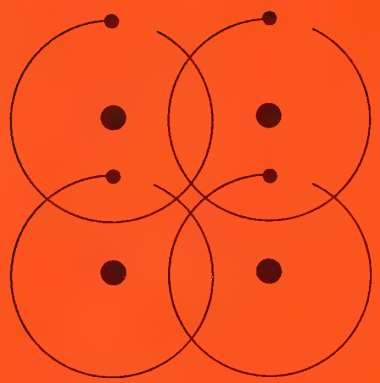
The universe we see at the moment
is in a state of constant evolution.
Hydrogen atoms in great clouds of thin gas gradually form clots.
These clots attract others to themselves by the weak force of gravity,
and so eventually they grow in size.
As they grow, their gravitational force gets stronger.
As more hydrogen falls into the growing clumps,
the gas heats up.
It picks up energy from the falling atoms.
It condenses more and more, and grows hotter:
we begin to see stars in the primitive clouds of gas.

When the gas gets hot enough,
the hydrogen atoms begin to combine.
Four hydrogen atoms can combine into one helium atom,
which is a little lighter.
The difference in mass (less than five per cent)
is because some of the gas has been
converted into energy according to the law
$E = mc^2$.



Stars get nearly all their energy by converting hydrogen into helium.
Helium, which is quite rare on earth,
was actually first observed in our nearest star,
the sun,
before it was observed on earth.
Its name comes from the Greek word Helios,
which means the sun.

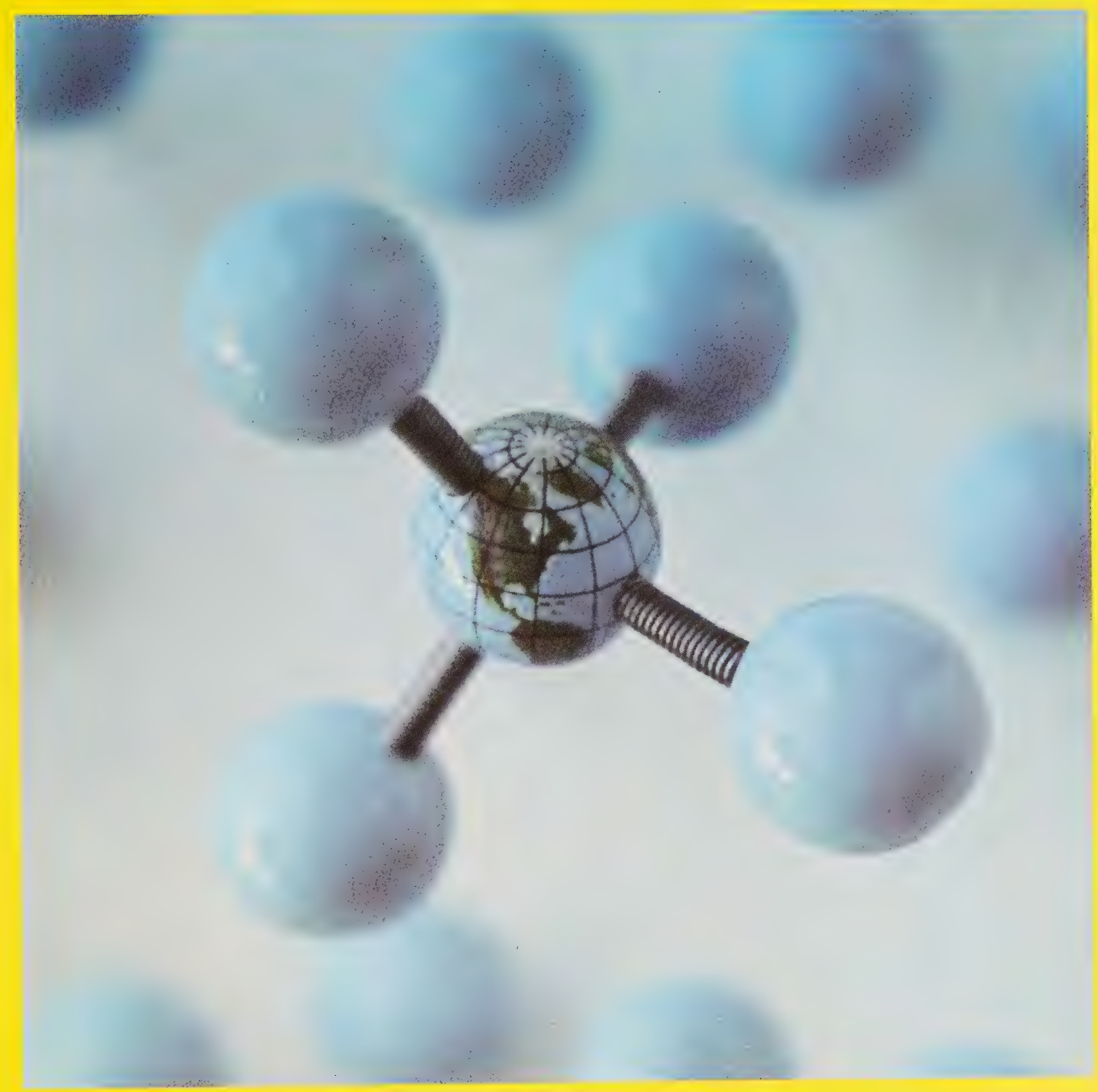
This transformation of hydrogen into helium
can go on for millions of years.
Hydrogen is the most abundant element in the universe,
and the next most abundant is helium.



Many stars finally become unstable.
So much of their internal hydrogen has been converted into helium
that they develop a kind of weakness at the core.
There is then an enormous explosion.
Astronomers on earth may observe a nova, a new star.
During the holocaust of an exploding star,
its temperatures get much hotter than usual,
other kinds of nuclear reactions take place,
and all the other elements of nature are formed.
If the star settles down again
it will contain such elements as carbon, oxygen, aluminum,
titanium, and iron.
All the chemical elements,
all the different kinds of atoms,
are formed in the furnaces of the stars:
first helium and then all the rest.
All the atoms of the hundred odd elements on earth,
including the carbon, nitrogen, sulphur, and other elements of your own body,
were formed from hydrogen
in the nuclear furnaces of the sun.

Even now, your body is largely water: H^2o.
Two atoms out of three are hydrogen.
We were made from hydrogen,
and we're still full of it.

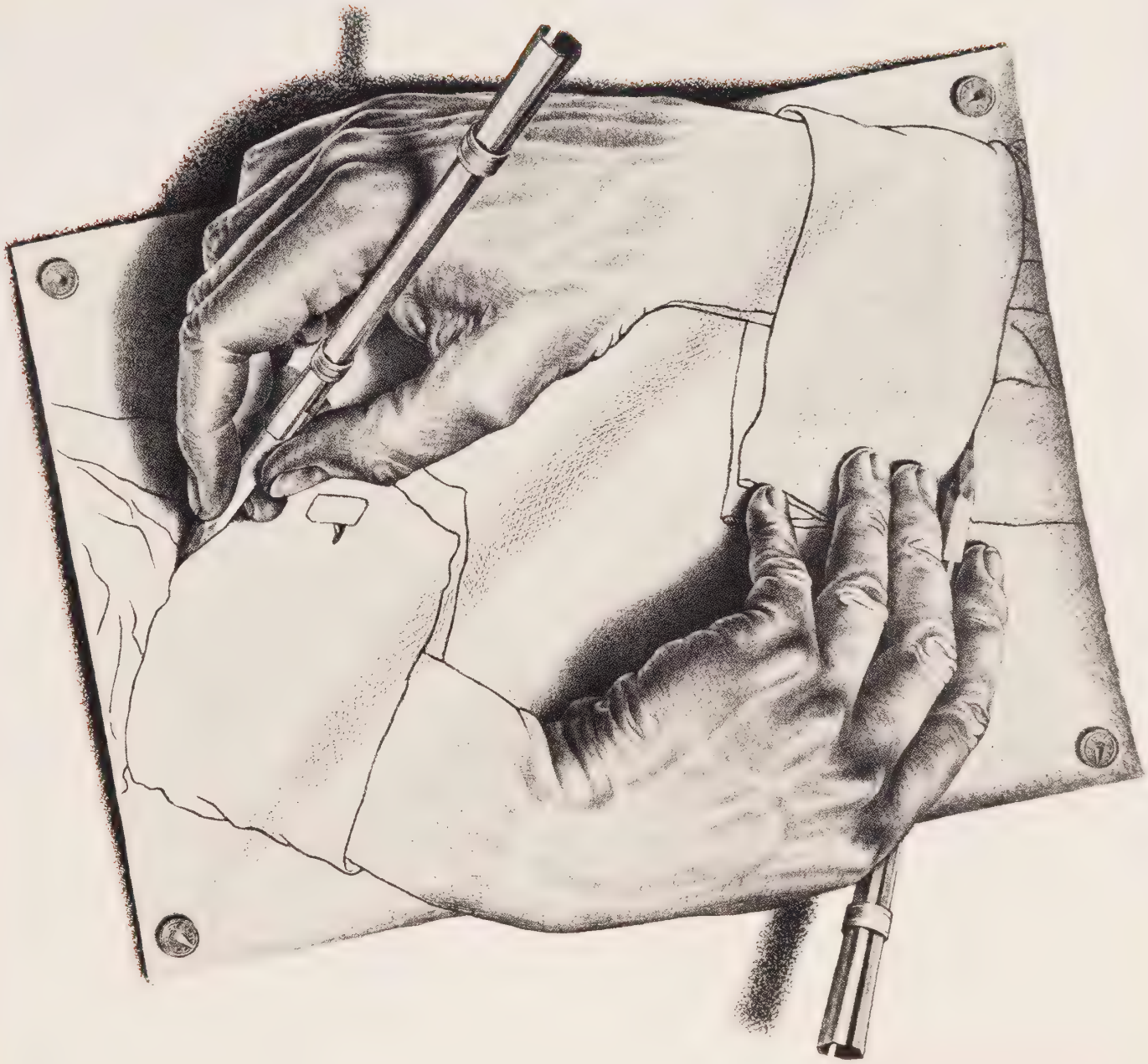
When atoms of different elements
come near each other, they may combine into
more or less permanent clumps of atoms: molecules.
You can think of atoms,
under the right conditions, spontaneously and by chance *evolving* into molecules.
The right conditions
mean that the temperature must not be so high
that there is an explosion and the combining atoms fly apart again,
nor so low that everything is frozen solid
and no significant action can take place.
Not too hot and not too cold:
the earth is about right,
particularly on the surface.
And sure enough,
the earth is full of chemical compounds.



Scientists have tried to guess
what the primitive atmosphere of the earth may have contained.
They fill glass vessels
with what they think were probably the gases of the primitive atmosphere,
and riddle them with radiation,
simulating primitive sunlight, and with sparks,
simulating primitive thunder storms.
Then they analyze the resulting mixture.
It turns out to contain a number of rather simple nitrogen compounds
called amino acids;
and these amino acids are the links in the long chains
that make up the proteins
that make up living cells.

In other words,
it has been shown that gases in the primitive atmosphere of earth
could have evolved into the amino acids
which are the building blocks of proteins.

Then what happened?
Nobody knows.
And nobody has yet been able to carry out an experiment
to duplicate what most scientists feel sure must have happened:
that is,
that some molecules in the primitive atmosphere
reacted chemically with the rest of the atmosphere
to make more molecules exactly like themselves.
Not living molecules;
not exactly the molecules of life;
but simply self-reproducing molecules.
What we are looking for is something like a machine
that can build other machines exactly like itself.
Nobody has yet been able to make
such a self-reproducing molecule.
But scientists think
these molecules must have turned up
on the primitive earth
because of what happened next.
Life appeared.



Scientists now believe
that all life on earth evolved from primitive forms
by the mechanism of natural selection.
Animals are not quite alike;
and some of these differences may be inherited.
This means that some animals may be better suited
to cope with their environment,
whatever that may be, than others;
further more,
they may be able to pass on their advantages to their descendents.
The environment does not produce variations;
it simply screens out undesirable variations that arise naturally.
And, of course, if the environment changes,
if seas slowly dry up, or forests gradually disappear,
then the animals are put through a different kind
of screening process.

Evolution by natural selection
means that life is continually adapted to changing environments.
A very important part of any animal's environment
consists of other animals of the same species.
Reproduction and aggression are two of the many important relations
which all animals have with each other;
these relations are a significant part of
the story of their evolution.

Plants evolved before animals,
because there was no oxygen in the earth's atmosphere
when the earth was formed
and animals need oxygen for survival.
Oxygen was manufactured, atom by atom,
as a by-product of the activity of green plants making use of sunlight
to build carbon dioxide and water
into the complex sugars and other things from which plants are made.
We still rely on earth's cover of green plants to
renew the oxygen of the air we breathe;
but, to our peril,
we are forgetting this.

Man is part of this grand revolutionary process.
But evolution is still continuing.
We live not at the end of evolution,
but in the middle of it.

We are the animal whose dominating adaptation is the brain.
We are decended, as Darwin put it, from
'a hairy quadruped, furnished with a tail
and pointed ears,
probably arboreal in its habits.'

We are not descended from living apes;
but it is literally true that we and the apes
are decended from common ancestors.
It is literally true that we came down from the trees.
We brought down with us equipment developed in the trees:
grasping hands, stereoscopic vision,
and a large brain capable of co-ordinating hand and eye.
These things made life possible in the trees;
and these things, modified,
have made man what he is today.

Man may be excused
for feeling some pride at having risen,
though not through his own exertions,
to the very summit of the organic scale:
and the fact of his having thus risen,
instead of having been aboriginally placed there,
may give him hope for a still higher destiny
in the distant future.
But we are not here concerned with hopes or fears,
only with the truth
as far as our reason permits us to discover it:
and I have given the evidence to the best of my ability.
We must, however,
acknowledge as it seems to me,
that man, with all his noble qualities,
with sympathy which feels for the most debased,
with benevolence which extends not only to other men
but to the humblest living creature,
with his god-like intellect
which has penetrated into the movements and constitution
of the solar system
with all these exalted powers —
man still bears in his bodily frame
the indelible stamp of
his lowly origin.

Man inherits certain things.
The most important thing he inherits
is the ability to learn,
particularly to learn a language.
No man inherits a language,
but every man inherits the ability to learn one;
and this is true of no other animal.
Language extends man's life in space and time.
It allows him to share the memories and experiences of
other men in different times and different places.
Language gives him
knowledge of the past and
foreknowledge of the future.


The
Time
Machine

A great deal of our communication
takes place in the form of language;
direct spoken language,
or language recorded in some form or other,
such as writing.
But spoken and recorded language
can be transmitted and processed;
for man is the toolmaker.
Man's characteristic way of handling the environment
is by making tools.
Evolution has modified the structure
of the other animals to provide them with most of
the tools they need.
Evolution has chiefly modified man,
not by changing structure,
but by changing nature
(although, of course, man's abilities are still built
upon the structures developed
in the trees so long ago).

One of the things man learns
is how to live with other men
and with his environment;
and mankind has learned many ways of doing this,
some more successful than others.
So we find man's activities
divided into characteristic ways of doing things
and of thinking about himself and the universe.
These ways are called cultures;
and, of course, man's cultures, his behaviour,
are subject to evolution by natural selection
just like any other piece of animal behaviour.
Culture that is adaptive,
that responds to the environment in
useful, flexible, realistic terms,
survives.
Culture that is not adaptive
will not survive.

The evolution of culture
is very fast compared with the evolution of man's structure.
We are now living in a period
when the need for cultural evolution is the dominating factor:
can man learn to live sensibly with himself
and with his environment?
Perhaps not;
and, if not, then the great natural processes
which have eliminated so many other species
will eliminate us.
Another form of life
will then dominate the planet.
Being human
does not confer immunity to the
laws of nature.

But it does confer
the ability to understand some of those laws,
to control some parts of nature
in accordance with that understanding,
and sometimes to make wise predictions
about the probable outcome
of our actions.

These are the things that science can do for us.
If we choose foolishly,
if we decide to ruin our environment,
the technological application of science can certainly help us to destroy ourselves.
Our technology (guided by science)
has allowed us to extend ourselves
— our vision, our hearing, our strength, and so on —
in all sorts of ways.
We can easily make ourselves stronger and faster.
It it harder to make ourselves wiser.
Our understanding of the great natural laws allows us to use them to help us;
we know about the conservation of energy,
so we can transform energy into whatever form is most convenient.
Engineering is the transfer of energy for the use of man.

At the same time,
our understanding of the universe leads us to consider our own position in it.
We realize that we are one animal among the many
inhabiting a small planet near an ordinary star
in a vast galaxy of stars,
which is itself one among uncounted millions.
But at least we are able to get some comprehension of the vast creation
of which we are no longer lords.
We have come a long way from the hydrogen atoms
creeping together in deep space
under the influence of that strange weak force of gravity.

Chemical elements
have evolved in the furnaces of the stars;
chemical compounds have evolved in favourable places;
where things have been very favourable
life has evolved;
and, among living creatures,
man has evolved, with his feelings, his hopes, his aspirations,
his thoughts, his philosophy:
man the toolmaker, the animal of culture.

Two things in the universe
impressed the philosopher Kant;
and we should always remember that both of them
are implicit in the hydrogen atom,
simplest of the elements of the universe:

Two things
fill the mind with ever-increasing wonder and awe,
the more often and the more intensely
the mind of thought is drawn to them:
the starry heavens above me
and the moral law within me.

This book was written by LISTER SINCLAIR
and was designed by ALLAN FLEMING

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Pictures

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Oil on canvas, 21¼ x 31⅞ inches
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63 A. BERNHAUT and RUSS KINNE
Photo Researchers, Inc.

Quotations

F 'To see what ...' ALBERT SZENT-GYORGYI
5 'Science combines ...' LISTER SINCLAIR
'To see what ...' ALBERT SZENT-GYORGYI
'The great tragedy ...' THOMAS HENRY HUXLEY
8 'The chessboard ...' THOMAS HENRY HUXLEY
12 'It is the ...' THOMAS HENRY HUXLEY
'The lyf so short ...' HIPPOCRATES
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'If I have seen ...' SIR ISAAC NEWTON
14 'I do not know ...' SIR ISAAC NEWTON
31 'I stood upon ...' RALPH HODGSON
50 'Man may be ...' CHARLES ROBERT DARWIN
62 'Two things ...' IMMANUEL KANT
B 'Knowledge ...' J. B. S. HALDANE

The world in which we live is being shaped by science and technology, for we interpret the universe through science by using imagination and reason. It is thus a human affair, for imagination and reason are fundamental aspects of man. Through our understanding of science we use technology to control the great natural forces for the benefit of all mankind. In this way, science and technology make society and society produces its own science and technology.

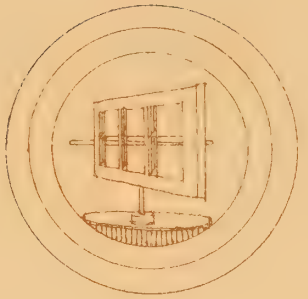
After a hundred years Canada has become one of the great technological nations and it was appropriate that the government of the province of Ontario should decide to mark Canada's centennial by founding a great science centre. This has become known as the Ontario Centennial Centre for Science and Technology and has no close parallel in the world. It is a place to experience the excitement of science: as our knowledge of the world changes the centre will change. It will provide an opportunity to watch the development of our technology, to study and to understand science and to feel the imaginative power that gives us an understanding of the world in which we live and to whose future we contribute.

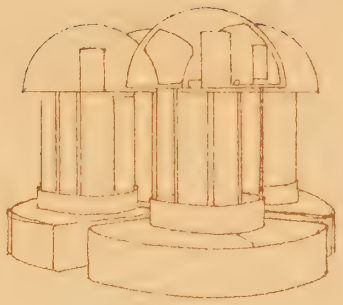
The first section of this book was also intended to help us understand science and the world in which we live. The second section, which now follows, is an attempt to catalogue a few of the many exhibits within the smaller world of this science centre.

In 1803, William Blake described the experience we hope our visitors will have:

'To see a World in a Grain of Sand,
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand
And Eternity in an hour.'

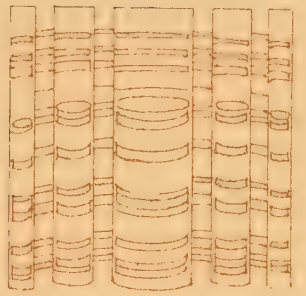
Revolving trapezoid
makes you believe a suspended stick
rotates through a window frame.

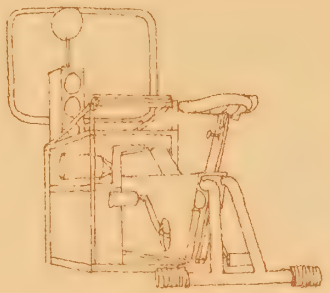




African kalimbas
are mounted so you can play tunes
on these primitive pianos.

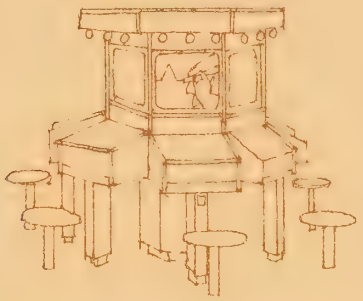
Water pressure demonstration.
It's the height not the diameter of
the vessel containing water.

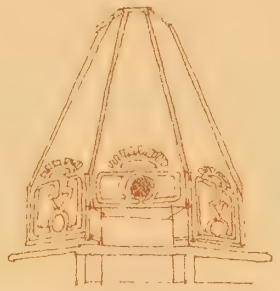




Pedal your way to making music,
lighting lights and putting yourself on TV
with the **bicycle generators.**

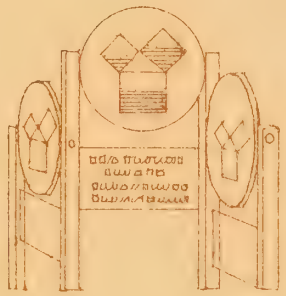
Star tracing unit
demonstrates the difficulty of hand movement
when viewing through a mirror.





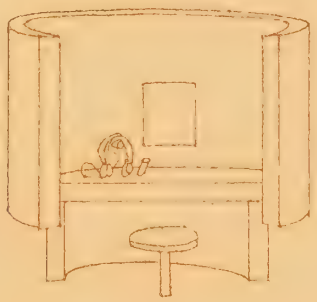
The **light piston**
is an optical illusion showing how intensity of
light affects judgment in distance.

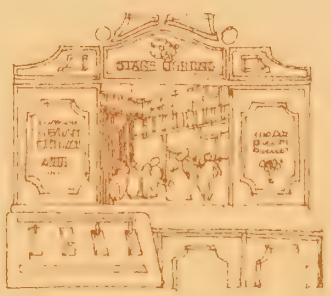
A revealing
visual demonstration of the
Pythagorean theorem.



Have your sense of
relative size destroyed in the
distorted room.

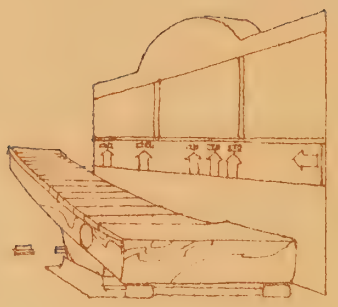
Ever hear you own voice delayed
1/10th of a second? The **audio delay unit**
puts you in that situation.

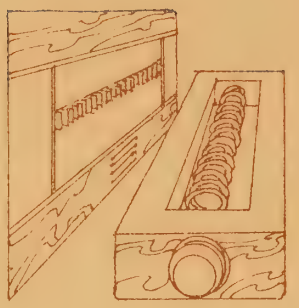




Create your own lighting effects from
a professional console and see the result in the
theatre stage.

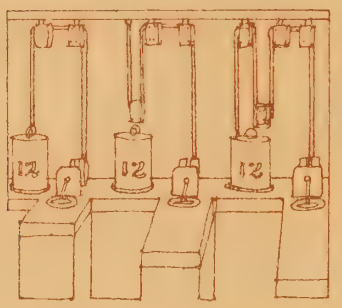
Using the law of the levers, calculate your weight on the **see-saw fulcrum**.

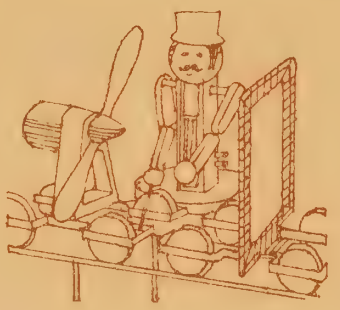




A mechanical analogue to illustrate the nature of a **compression wave** as in the propagation of sound.

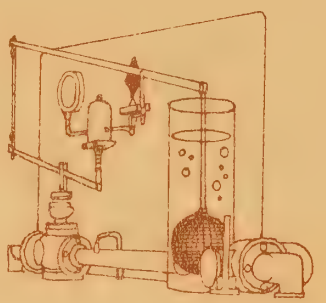
Different arrangements of **ropes and pulleys** show how a mechanical advantage is created.





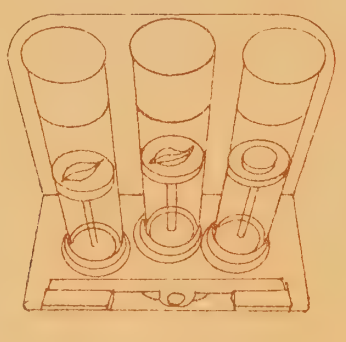
The magician demonstrates on command Newton's principle of **action and reaction.**

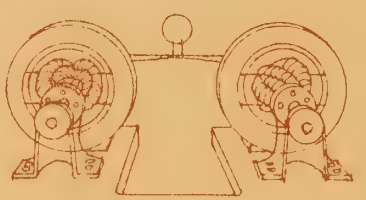
A large **revolving magnet** pulls a host of smaller magnets to reveal its lines of force.



An apparatus to help you visualize some of the theories of **control systems.**

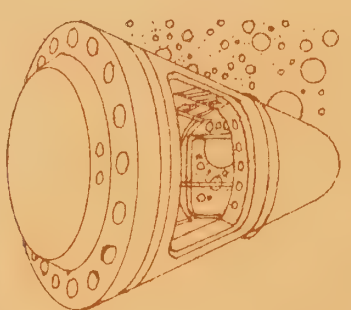
Will a **coin and feather** fall at the same rate in a vacuum? See it happen!

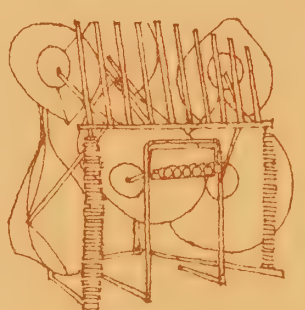




Motor or generator? An exhibit shows they are really the same except for the direction in which they operate.

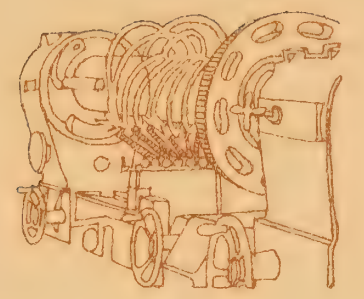
Simulating the astronauts' **space docking** procedure.

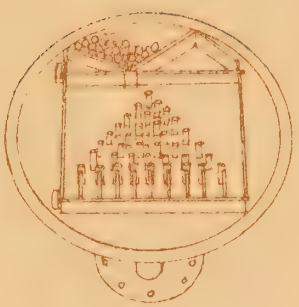




A modern **musical instrument** created by French sculptor *Francois Bachet.*

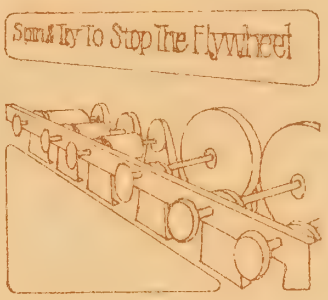
Turn molten glass on this **glass maker's lathe.**





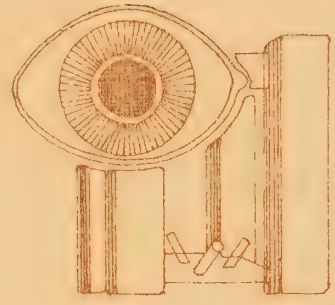
How accurate are the laws of probability? Try for yourself with the **probabilities game.**

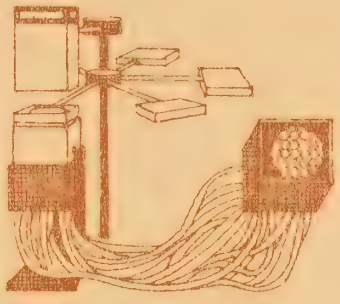
The **Alexbo,** a barge that converts any freighter to an icebreaker.



The concept of inertia and momentum are easily understood by starting and stopping the **spinning fly-wheels.**

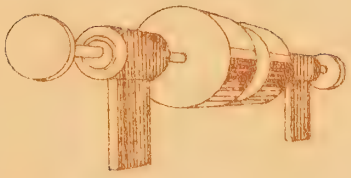
In this exhibit watch the eye's **iris in action.**

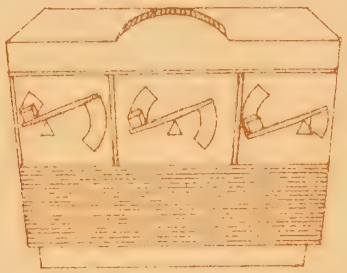




Bend light around corners? Yes, if you use **fibre optics.**

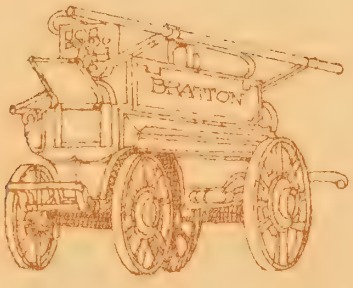
Push the magnets together and experience first-hand the force of **magnetic repulsion.**

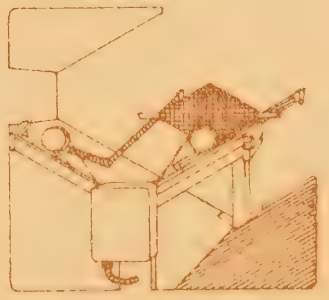




The position of the **fulcrum** on the **lever** determines the force needed to lift a given weight.

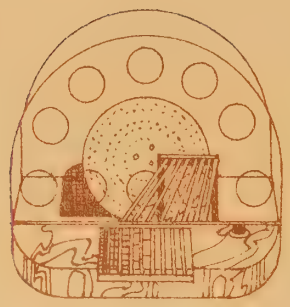
Old-time **fire engine** rigged so it will pump water to set in operation various mechanical devices.

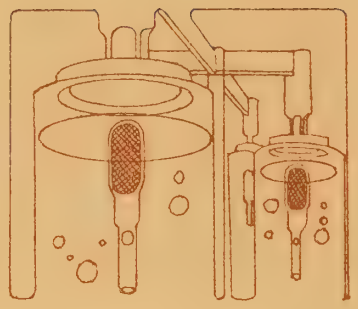




Can an object run uphill? It would seem so, if the object is an **anti-gravity cone.**

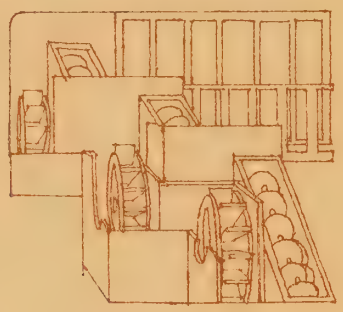
Play a tune by blowing air through this **rotating sound disc**.

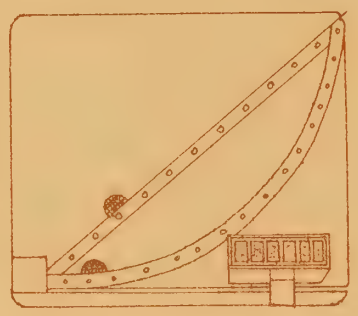




The **Cartesian diver** shows how changes in density affect the position of a glass indicator in a column of water.

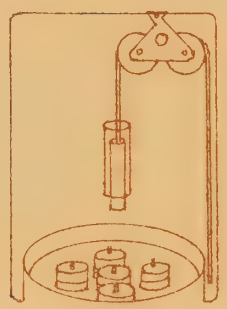
Archimedean screws and water wheels you can operate yourself.





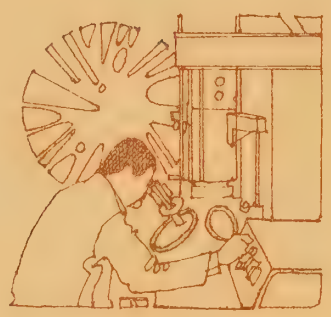
Is the fastest path between two points a straight line? Not if gravity is involved, as the **Brachistochrone** shows.

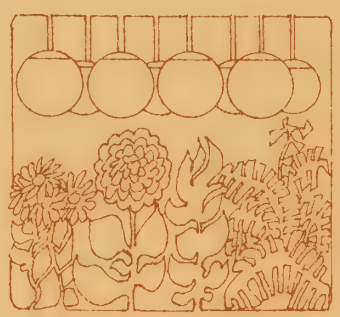
Floating magnets prove that magnetic repulsion can overcome the force of attraction.



The **motor homunculus** distorts the body in proportion to its motor representation in the brain.

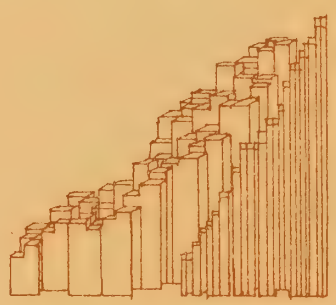
A **Philips 300 electron microscope** in a fully functional laboratory.





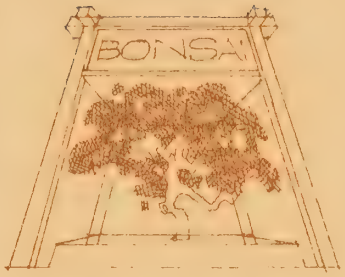
See how radiation produces changes in genetic makeup. **Plant mutations** are shown in flowers.

Discover the **factors that affect friction** by trying to twist the heavy weights.



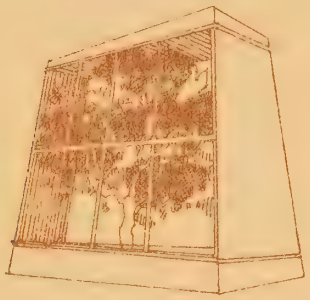
The **nuclide chart** is a three-dimensional representation of chemical elements and their isotopes.

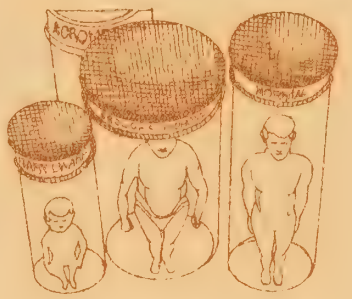
The inheritence of **eye, hair and skin colour** is explained.



The nutrition of a plant can be controlled to produce a dwarf. This is the Japanese art of **Bonsai.**

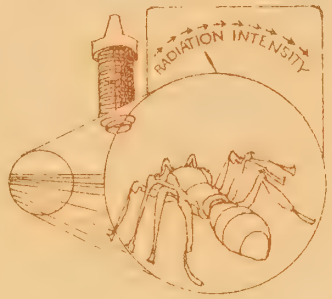
Twenty varieties of live budgerigars in a huge flight cage illustrate **genetic variation** in a single species.





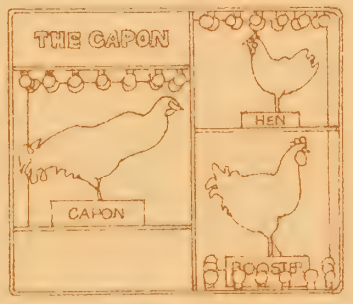
The **pituitary** is the master gland in the body and this exhibit helps explain why.

Priestley's experiment duplicated shows that a plant and animal can sustain each other's metabolism in a sealed environment.



The **ant colony** is used to demonstrate the use of radioisotopes in tracing animal movement.

The **mineral requirements** of plants are demonstrated by means of living plants growing in cylinders.

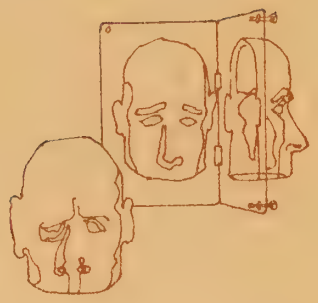


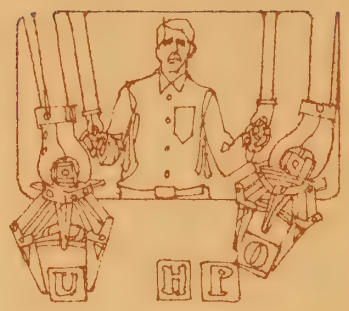
The effects of the sex hormones on the development of a rooster are shown in the **capon** exhibit.

Do all plants need light to grow? The **mushroom colony** offers the answer.

The art of microscopy is revealed by enlargements of photomicrographs presented on the **magnification wall.**

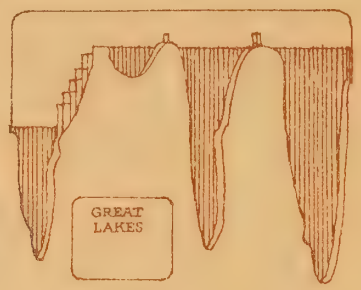
An exhibit showing the condition of **Acromegaly**–excess pituitary growth hormone–and how it can be treated.





Remote mechanical hands for manipulating radioactive materials.

What are the relative levels and depths of the Great Lakes? The **Great Lakes section** shows you.

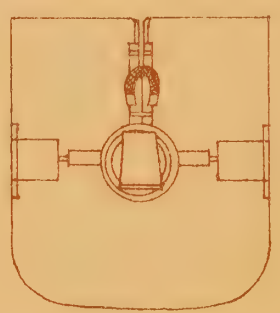


Touch of luxury! The **Canadian furs** exhibit allows you to feel the difference.

A large, accurately scaled diorama of the **Eisenhower-Snell lock complex** in the St. Lawrence Seaway.

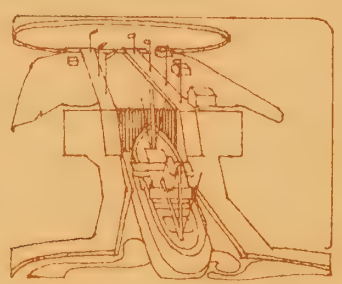
The **hydroponic** exhibit shows plants growing in nutrient solutions rather than soil.

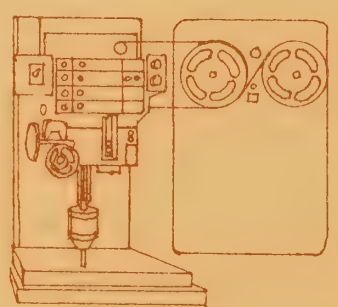
A 50-foot map of the entire **St. Lawrence Seaway** presented on illuminated glass panels.



Cathode rays bent by a **magnet** to help illustrate the principle of the electron microscope.

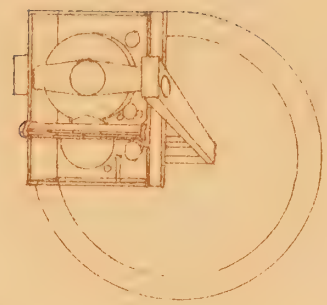
A working **liftlock** model lets you see at close hand how a typical lock operates.





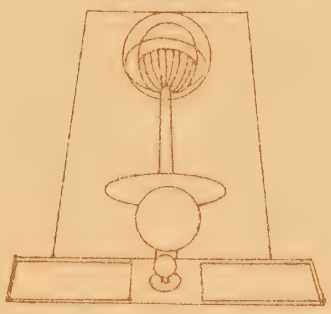
A **drill press** that operates on instructions from a **computer tape.**

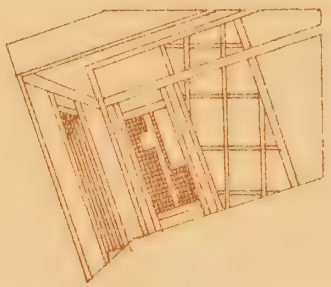
The **ocean currents** of the Arctic in motion. seen through polaroid glass.



Step on the **gyro platform** and experience precession as you tilt the spinning gyro.

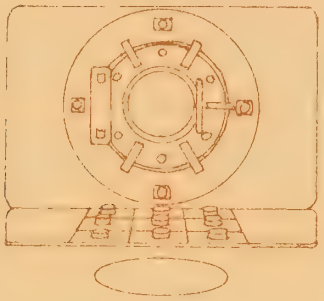
The **solar cell**, electrical energy from light.

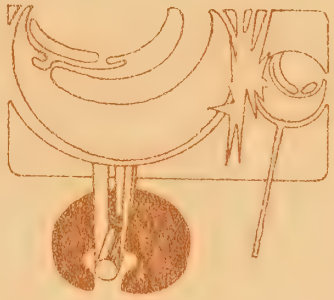




The **disorientation room** introduces you to exhibits on inertial guidance by disrupting your own inertial guidance systen

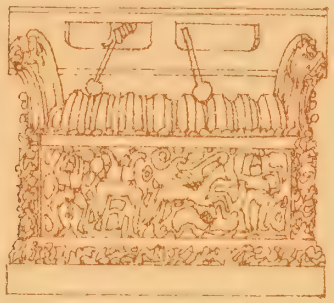
A working model of **electronic locks**, the last word in safety.

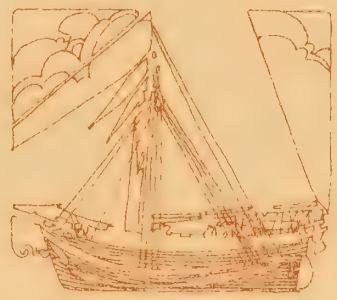




In the Ontario Hydro area, a demonstration of **high voltage electricity.**

A **Gamelan instrument** from Indonesia that you can sound yourself.



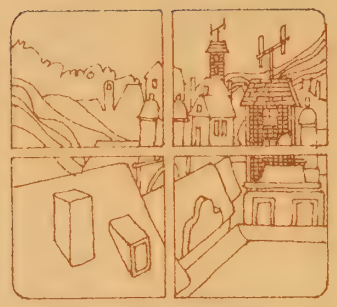


Amundsen's vessel **Gjoa** was the first to sail the North-West Passage.

Franklin's ship **Erebus** was lost in the Arctic in search of the North-West Passage

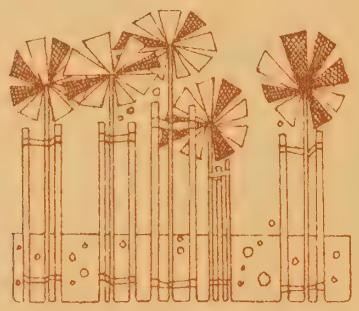
A diorama lets you see the contrast between summer and winter on **Baffin Island.**

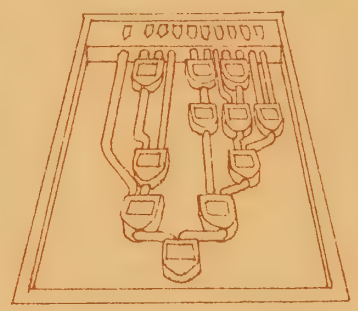
The **Chappe semaphore** signalled the news of Napoleon's victories across France.



The **SS Majestic** was once the *ne plus ultra* of ocean transportation.

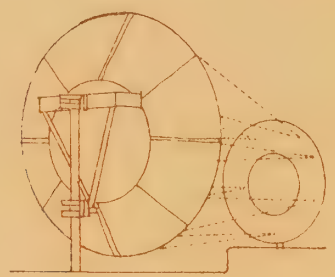
Visitors use fluidic controls to manipulate the **magic fountain.**

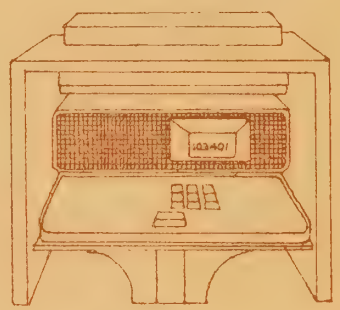




A ping-pong logic game uses ping-pong balls to simulate the movement of electronic impulses through computer circuits.

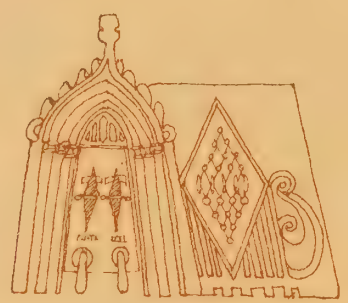
Eight-foot diameter parabolic **sound discs** allow visitors to whisper to each other across 150 feet of noisy exhibit hall.

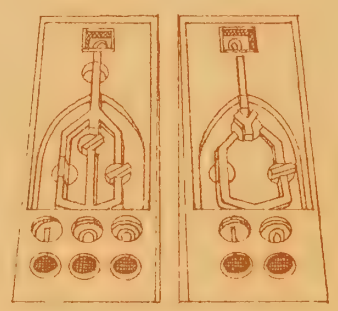




Calculate your income tax on the Centre's array of **desk calculators.**

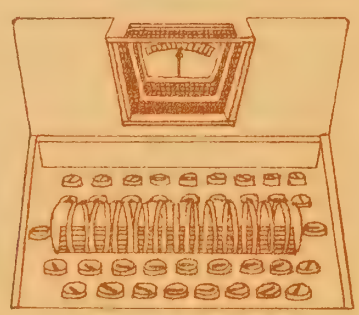
The **two-needle and five-needle telegraphs** were early types of signalling pre-dating the Morse code.





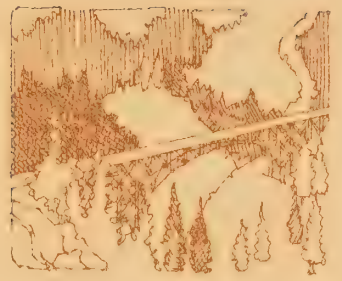
The basic **logic gates** illustrate the ways in which electric circuitry in computers represent logical decision.

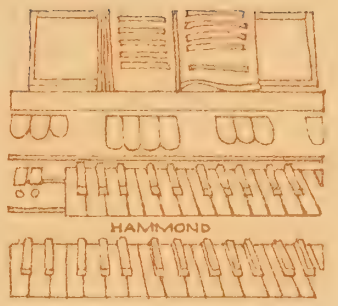
See how a change in current direction **reverses a magnetic field.**



Stereo television as demonstrated at the Centre.

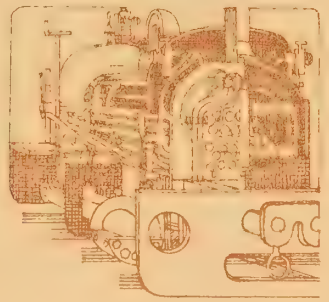
A spectacular diorama of a Canadian engineering achievement —the **spiral tunnels** of the C.P.R.

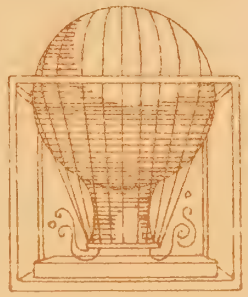




Come in, sit down and make music in the **organ room.**

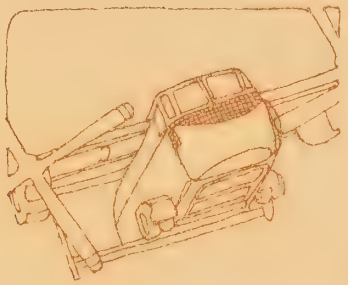
The sectioned quarry engine, **Gertrude**, depicts all the basic elements of steam locomotive design.

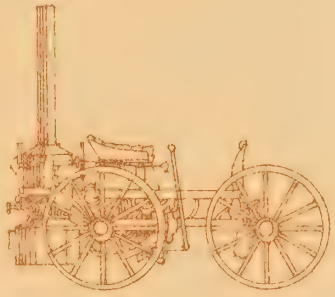




An operating **hot air balloon.**

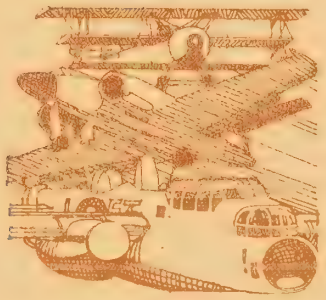
Canadair's **VTOL** takes off or lands vertically, hovers, or flies normally.

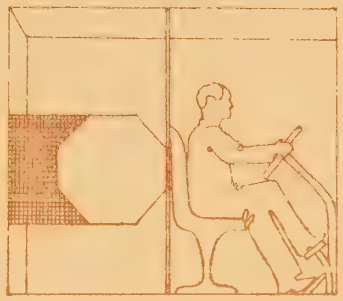




This 1867 **steam buggy** may well have been Canada's first automobile.

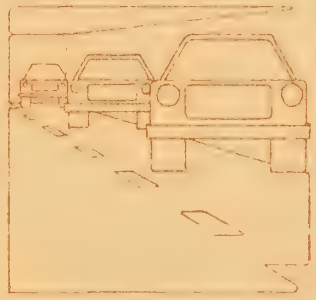
The history of avaition is illustrated in an array of **aircraft models.**





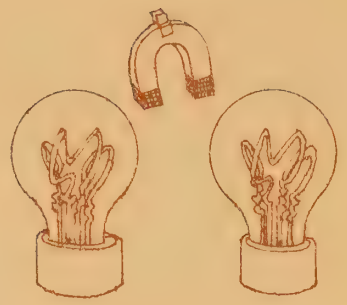
Test your **driving reactions.**

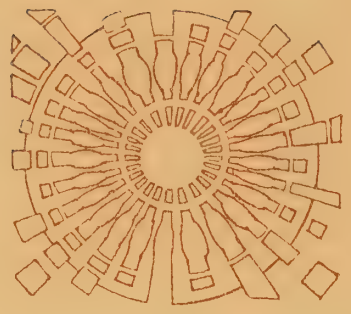
The **Islander** was a victim of one of Canada's first maritime disasters.



How good is your **judgment of distance?**

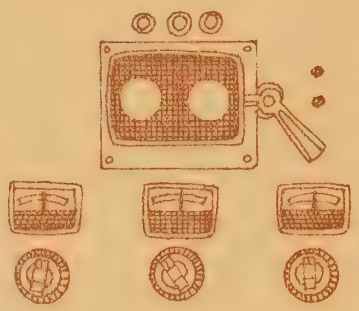
Investigate some of the basic elements of electricity and magnetism with the exhibits on the **electricity wall.**

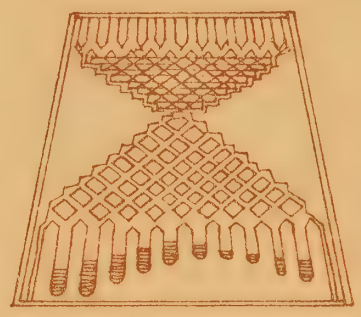




An exhibit to help you understand the **stroboscopic effect.**

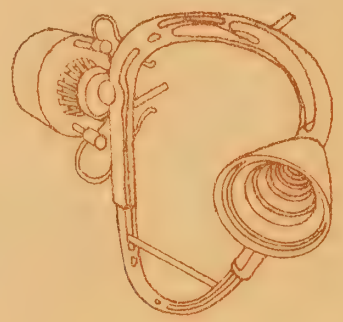
Is your **colour matching** ability as good as you imagine?

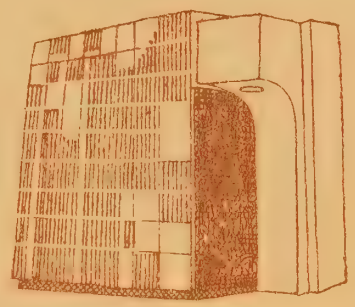




The **laws of probability** are illustrated in an exhibit which uses coloured liquid to create a normal distribution curve.

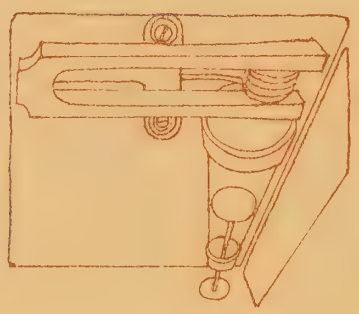
Herschel's tube illustrates some basic principles of acoustics.

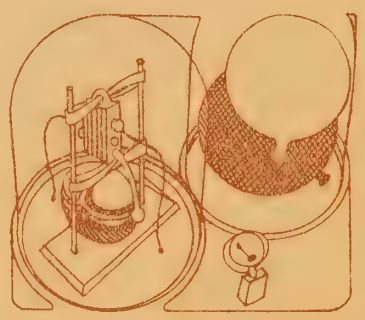




A tiny theatre devoted to films on **animal behaviour.**

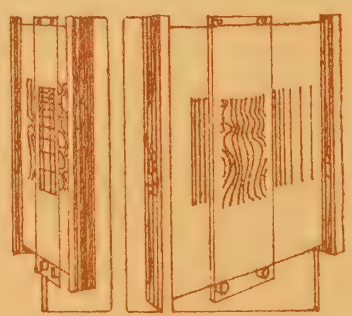
Learn something about resonance with these **adjustable air columns.**





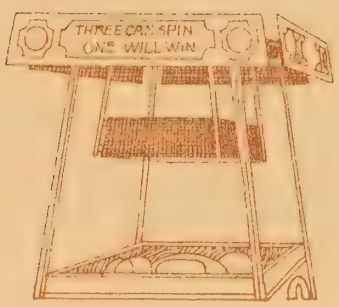
Investigate **what happens in a vacuum** with this group of exhibits.

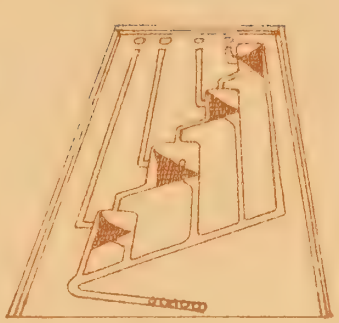
Stand in the light and create **coloured shadows.**



Learn something of the **interaction of colours.**

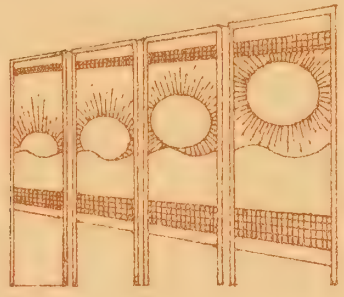
Find out what **gears** do by turning them yourself.





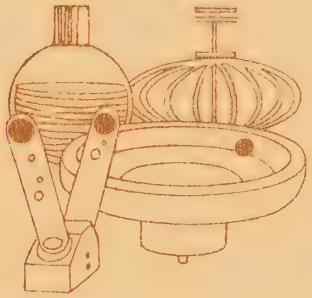
The **binary counter** shows how ordinary numbers are converted to computer numbers.

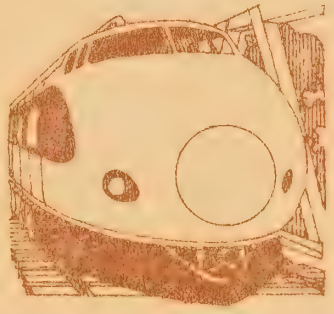
The **midnight sun** of the Canadian Arctic.



A wide-angle diorama of the **tundra** with its animal life, winter and summer.

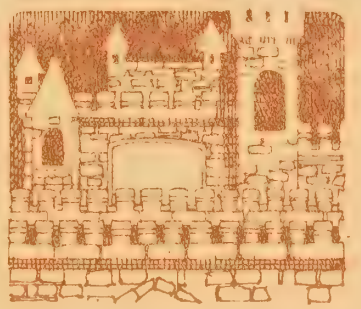
An exhibit to let you understand **centripetal** and **centrifugal** forces.





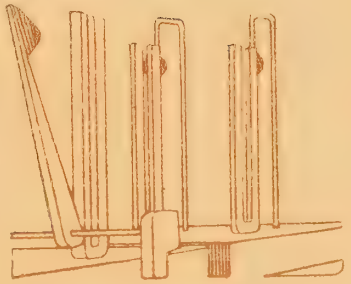
A working model of the **Tokaido Express,** the world's fastest and most completely automated passenger train.

A **cable matching game** played with modern telephone cable.



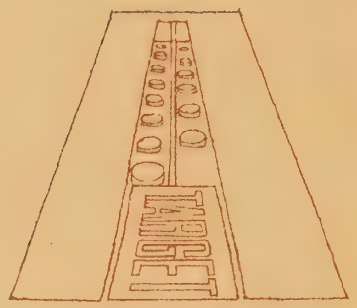
A diorama of an ancient castle showing how many persons had to expend **energy** which we now command at the flick of a switch.

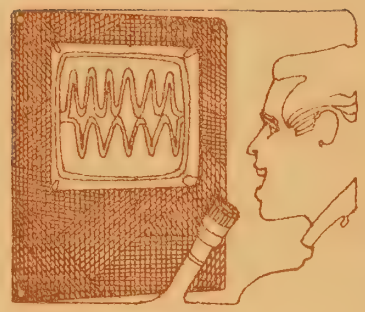
Tuning forks used to illustrate resonance.



When **snow** flakes out it turns to ice. An exhibit shows the steps.

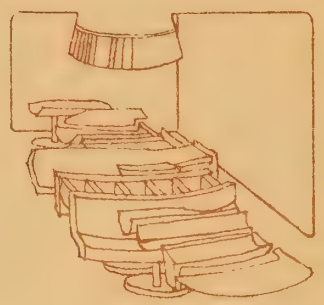
A mechanical analogue of the **Doppler effect** explains why you got that speeding ticket.

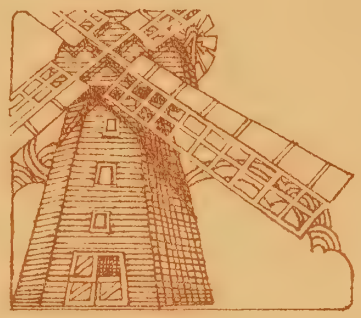




You've heard your own voice – **now you can see it!**

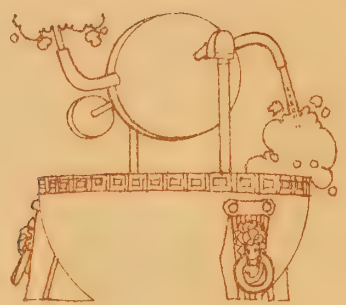
Detecting flaws with the **Magnaflux technique**.





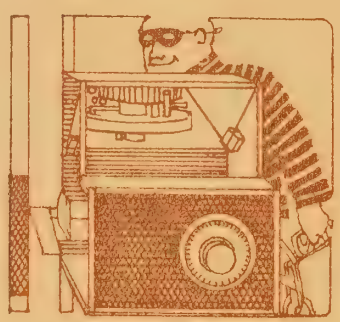
The **windmill** was the earliest machine to use a feedback control system.

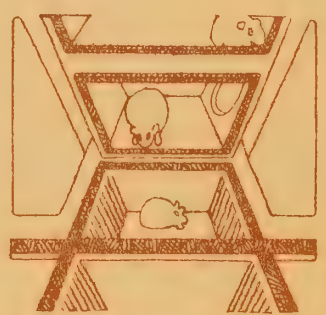
A model of the world's first **jet reaction engine** built by Heron of ancient Alexandria.



A reproduction of the laboratory in which **Banting and Best** discovered insulin.

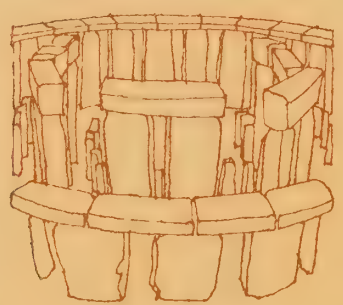
Test your skill against this modern **mechanical lock**.

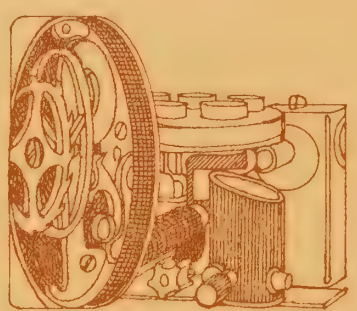




Three generations of **guinea pigs** illustrate the basic rules of **inheritance.**

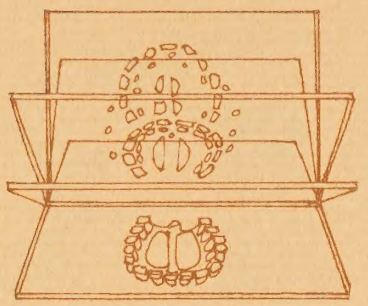
Stonehenge, the world's first astronomical computer.





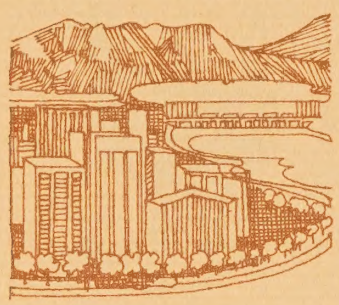
A working **industrial microscope** inspects minute components.

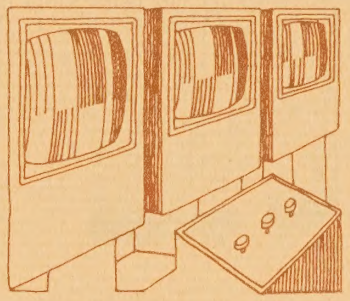
The stages
in the
erruption of teeth.



Giant cabbage
with
plant growth hormones.

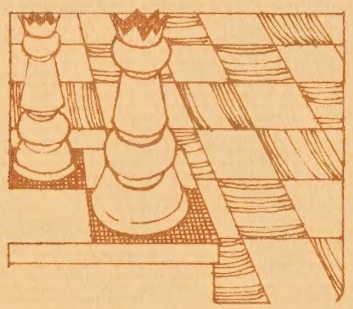
A large model landscape
illustrates how power generation
depends on the **rain cycle**.

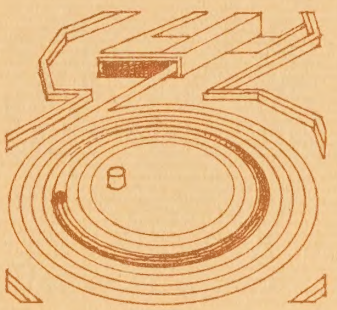




Demonstrate for yourself
how a **colour television** image
is built up.

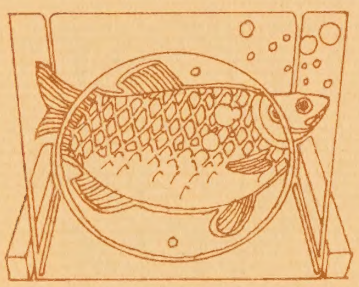
Radiation
is used to produce
longer-lasting **wood**.

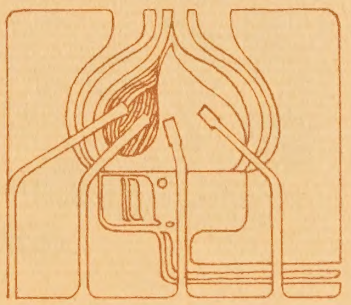




A mechanical **analogue**
of the atom-smashing
cyclotron.

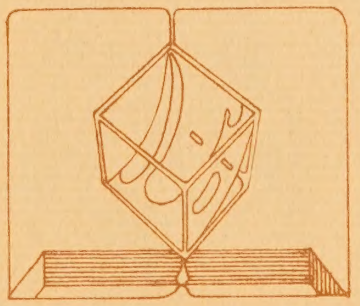
A glass lens
in the
history of magnification section.





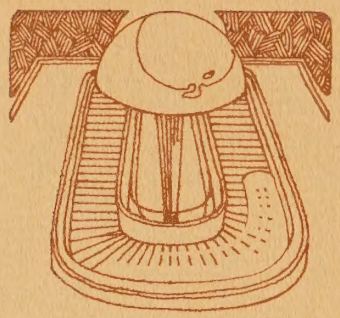
Identifying the elements
by their
flame colour.

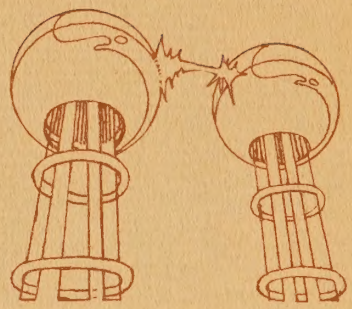
Embryonic development
of the
chicken.



A **soap film**
taking
minimum surface.

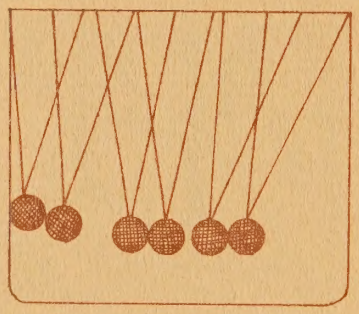
A **linear motor**, a new turn in converting electricity to motion.

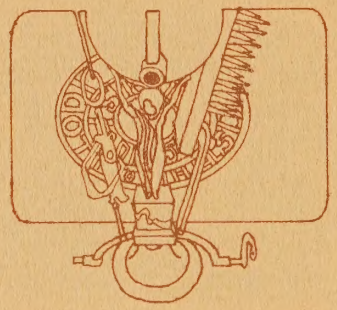




Millions of volts from a **Van der Graaff generator,** earliest of the atom smashers.

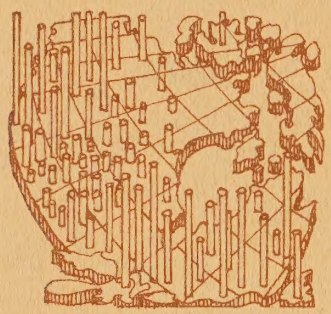
Simple **pendulum** to illustrate **momentum**.





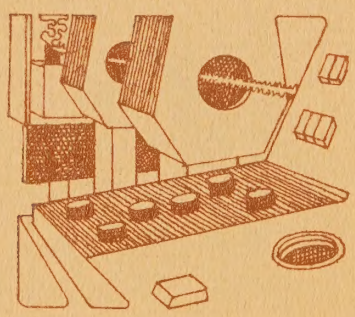
A fantastic **tower** held together by modern **adhesives.**

A dimensional look at the **mean annual rainfall** in 69 Canadian locations.



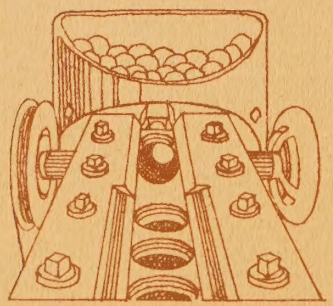
A colourful **relief map** of the **Great Lakes.**

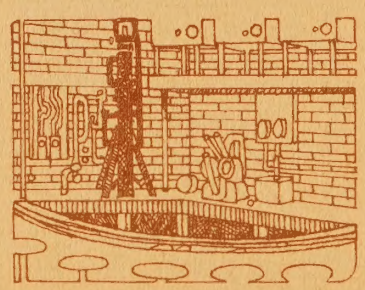
A giant modern **laser** with the intensity to burn holes through brick.



A multi-stage fractional **distillation column.**

Sorting ball bearings by size, mechanically.





One of the world's first operating **electron microscopes,** built at the University of Toronto.

Knowledge
once gained
casts a faint light beyond its own
immediate
boundaries